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The Industrial Age Versus The Information Age: Rethinking National Security in the 21st Century

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PREFACE

This document was prepared by the Institute for Defense Analyses as part of its Central Research Program. The objective of this effort was to produce a brief summary of changes in thinking that defense planners and policy makers need to consider when contemplating the security environment of the next few decades.

The IDA Technical Review Committee was chaired by Mr. Thomas P. Christie and consisted of Mr. Rosser Bobbitt, Mr. K.C. Brown, Mr. Warren Olson, Mr. Ed Pechous, and Mr. John Tillson.

THE INDUSTRIAL AGE versus THE INFORMATION AGE:
Rethinking National Security in the 21st Century

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Rethinking National Security in the 21st Century

John Rothrock
John Kreis
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Thinking About Future Conflict

- **Several recent studies have considered the demands of national security in the new century**
  - December 1999 National Security Strategy
  - 1997 Quadrennial Defense Review (QDR)
  - Joint Vision 2010 and the concept for future joint operations
- **The QDR points out that we must help shape the international security environment**
  - In ways favorable to U.S. interests
  - To be able to respond to the full spectrum of crises, when directed
  - To prepare now to meet the challenges of an uncertain future
- **We seek to shape the international environment through a variety of means:**
  - Diplomacy, alliances, and military posture
  - Economic cooperation
  - International assistance
  - Arms control and proliferation
  - Health initiatives

  - National Security Strategy, December 1999
- **Joint Vision 2010 is the blueprint for transforming U.S. forces for the future**

How Joint Vision 2010 Views the Next Century's Military

This era will be one of accelerating technological change. Critical advances will have enormous impact on all military forces.

- Joint Vision 2010

Transformation of our military forces is critical to meeting the Military challenges of the next century.

- National Security Strategy, 1999

- **Technological innovation is a key enabler in Joint Vision 2010**
- **Joint Vision 2010 is fueled by advanced technologies and leveraged by our unique capabilities to conceptualize and integrate complementary or supporting systems**
- **Selecting appropriate technologies and rapidly evaluating and incorporating innovations are major challenges to understanding what may be a [revolution in military affairs] and exploiting capabilities described in Joint Vision 2010**

  - Concept for Future Joint Operations
- **How must we stimulate change to meet these demands?**

12/8/00-2

Using Joint Vision 2010 to Support the National Security Strategy

The unqualified importance of information will not change in 2010. What will differ is the increased access to information and requirements in the speed and accuracy of prioritizing and transferring data brought about by advances in technology.

- Joint Vision 2010

- **The President's National Security Strategy of 1999 notes:**
  "We are also committed to maintaining information superiority – the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting and/or denying an adversary's ability to do the same."
- **But have we taken advantage of our opportunity to focus on shaping change in the next decades?**
- **How must we change our thinking?**
- **What distinctions must we make?**

RETHINKING NATIONAL SECURITY IN THE 21st CENTURY
Cognitive Distinctions

The chart opposite provides a comparative list of cognitive industrial age "defaults" that reflect certain intellectual tendencies that seem to characterize the American socio-economic achievements of the past several decades. These industrial age tendencies are compared to equivalent default tendencies that the developing information age, sometimes called the post-industrial era, seems to reward.[1] The list therefore provides an outline of some of the different modes of thinking that distinguish an industrial age mindset from a post-industrial mindset. Of course, these opposing sets of distinctions need to be considered as part of a spectrum of emphasis, and not as either/or propositions. That is to say, the industrial mindset in practical fact has never wholly consisted only of the tendencies listed to the left of this list, totally bereft of those listed to the right. Similarly, information age thought will always draw upon – at least to some degree – the defaults listed here as comprising the industrial cognitive style, just as information age technology is built on a strong industrial economy.

For example, viewed in terms of efficiency versus effectiveness, the United States pursued World War II in terms of effectiveness, with cost a minor consideration. Before the war, however, cost was king and efficiency ruled. Thus, we were unprepared for the conflict and struggled for the first year or more just to keep our enemies at bay. After the war, the wartime planning considerations for peacetime force structures fell to the budget ax. The proposed 95 combat groups for the post-war Air Force became about 25 groups with outmoded equipment. Similar situations prevailed in the Army, Navy, and Marine Corps.

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1 The term *post-industrial*, although frequently used, may be misleading. The United States remains the world's pre-eminent manufacturing country. We (and other nations as well) now use information management techniques to produce higher quality, better, more complex products. For this briefing, we shall use the terms *information age* and *post-industrial age* interchangeably. Whichever term one prefers, the thinking process needs to change to reflect the new demands.

Cognitive Distinctions

- **Each is a spectrum; there is no either/or position**

(-10) Industrial Age	⟷ Neutral	Information Age (+10)
Strength	⟷	Power
Tangible	⟷	Non-Tangible
Quantities	⟷	Qualities
Dexterity	⟷	Creativity
Training	⟷	Education
Arithmetic	⟷	Geometric
Necessity	⟷	Sufficiency
Entities	⟷	Relationships
Efficiency	⟷	Effectiveness
Input	⟷	Output
Linear	⟷	Non-Linear
Central and Vertical	⟷	Diffused and Horizontal
Information and Knowledge	⟷	Insight and Wisdom
Inductive/Deductive	⟷	Abductive
Stability and Order	⟷	Dynamism and Chaos

The comparisons – cognitive distinctions – presented in the chart, and that are supported in the discussions in the accompanying essays, provide a general framework for considering if and how traditional (essentially industrial) measures of effectiveness or factors of merit are orthogonal to the new Gobalization/Post-Cold War Environment. The distinctions also help in conceiving new factors of merit that might provide more relevant insight into what constitutes effectiveness in this new period. The essays discuss both the general reasoning implications of these cognitive distinctions and, more particularly, specific implications that they can be seen to carry when considered from a national security or military perspective.

CONTEXT NOTE FOR THE DISTINCTIONS

As listed at the end of each of the discussions that follow, all of the distinctions considered here are closely tied in their logic to at least several – if not all – of the others. They all address somewhat different dimensions of the same problem: the extent to which change produces discontinuity. As it is used here, discontinuity refers to situations in which a watershed event or confluence of events and/or trends has produced a new set of circumstances that challenge the continued relevance of past experience and the assumptions that it empirically supported.

Such discontinuity-causing phenomena can be of a very general, implicit nature and develop over a considerable period of time: for example, the evolution of mechanized and air warfare technologies; World War II; the decade-long wind-down of the Cold War; the Information Revolution. Conversely, they can also be very explicit and transpire over a fairly short time: for example, the introduction of specific "disruptive technologies," such as nuclear weapons, jet aircraft, or diesel-electric traction for railroads; a single "strategic event," such as the assassination of Archduke Francis Ferdinand in 1914; Pearl Harbor; the improbable parliamentary impasse that brought Hitler to power in 1933.

The fundamental cognitive challenge presented by such discontinuous phenomena is to understand that they redefine progress as a new trajectory to the future rather than as mere advancement over the past. While achieving this sort of understanding is always difficult for decision makers charged with responsibility for the present, it is especially difficult when the discontinuity results from a cascading, cumulative effect caused by change of quantitatively measurable degrees finally transforming to a change in kind. The following discussions attempt to contribute to a basis in logic for examining phenomena to detect and assess such degree-to-kind change, as well as to examine those sorts of changes in which the discontinuity is more obvious.

Context for the Distinctions

- **These distinctions deal with discontinuity – where watershed events or trends produce new circumstances that challenge the relevance of past experience and the assumptions that such experience supported**
  - Each is in flux, with elements of either side as parts of the whole
- **Discontinuity-causing phenomena can be:**
  - Very general and implicit over considerable time
    - » Submarine, mechanized, and air warfare technologies
  - Very explicit and occur over a short period of time
    - » Nuclear weapons, jet aircraft, diesel-electric rail locomotives
- **Discontinuous phenomena will redefine our regard for cause-and-effect**
  - From one that focuses on discrete events
  - To one that discerns a new trajectory to the future
- **Understanding what is happening becomes especially difficult when discontinuity results from cascading, cumulative effects of changes in kind rather than in quantitatively measurable degrees**

NECESSITY VERSUS SUFFICIENCY

The industrial-age perspective tends to focus on the internal efficiencies of in-being productive relationships (see the essay on Efficiency versus Effectiveness). The industrial-age mindset, therefore, tends also to presume a close, if not entirely synonymous, relationship between necessity and sufficiency. In fact, it tends to presume that it is sufficient to attend to all factors that have been identified as being necessary to a given process. Conversely, the post-industrial perspective, in its emphasis on dynamic relationships of change between internal and external factors, tends not to assume a close relationship between any single ingredient or set of ingredients and the sufficiency of the outcome that they produce at any given time.

DISCUSSION

With an already structured system of relationships (for example, a steam engine or even a football team), one should presume a close – even synonymous – relationship between necessity and sufficiency. Within such a system, assuming it is well conceived and complete in its structure, all identified parts are necessary and, together, they should be sufficient. This is because the functions within the system in question were pre-considered and calculated *a priori* for their combined internal efficiencies. This is the kind of closed-loop set of relationships that the industrial-age perspective tends to presume.

However, the post-industrial perspective tends to focus on open-ended relationships that have not been created with *a priori* calculation. This is most notably seen in any relationship between preordained internal factors subject to control and given external factors that cannot be controlled. One example would be the relationship between training and the overall educational needs of a society. The training – say, in how to operate a computer – might be necessary to the educational process, but it is still far from sufficient for that process's ultimate educational success.

NECESSITY versus SUFFICIENCY

- **Industrial-age perspective focuses on internal efficiencies of in-being productive relationships**
  - Presumes it sufficient to attend to all factors identified as necessary to a given process
- **Post-Industrial emphasis is on dynamic relationships of change between internal and external factors**
  - Tends not to assume a close relationship between any one set of ingredients and the sufficiency of the outcome
  - Relationships are open-ended with no *a priori* calculation about structure and alignment
- **Military example**
  - Tactical perspective is necessary
  - But without a larger, strategic perspective, it is not sufficient

In a post-industrial age that makes such heavy use of media and information, democratic societies are especially prone to two categories of risk in failing to note adequately the differences between what is necessary and what is sufficient. The first risk category involves the innocent mistake of a society – whether due to lack of reflection, involvement with other concerns, or just being overwhelmed by the flow of information and daily events – simply being oblivious to the problem. An example would be that of an individual or class of people who would presume that simply becoming dexterous with a computer and the application of certain programs was equivalent to actually being educated, and thus would afford them the material rewards generally reserved for the educated class. (See the essay on Training versus Education.)

The second category of risk is not so innocent, but is in fact politically calculated. To continue with the training and education example, politicians routinely attempt to sell training programs by promising outcomes for the society that can result not only from training, but also from the more expensive, less auditable, and generally more difficult task of education. Of course, training is important to the educational process, but such training alone cannot be expected to reward its graduates to the same degree that society will reward those who succeed in becoming truly educated. Nevertheless, politicians and educational specialists tend to ignore this important distinction because of vested interests in funding sources and votes.

NATIONAL SECURITY AND MILITARY IMPLICATIONS

An obvious example of how the necessity versus sufficiency distinction relates to the national security and military sphere would be the ability of a military to win battles. Within Western culture, at least, the ability to win battles is necessary to win wars. However, history shows that it is possible to win all the battles and still lose the war if the battles (or the war) are poorly chosen; witness the disastrous American experience in Vietnam and the Soviet debacle in Afghanistan. In nonwestern cultures, the cultural willingness to accept large numbers of casualties over a long period can have the same war-winning effect as winning battles.

Sufficiency is not served merely by being able to win in battle, but also by being astute enough to choose the right battles in the right war. In this case, the distinction between necessity and sufficiency is linked with two other, corollary distinctions. The first of these distinctions is between tactics (winning the battle) and operational art (winning the right

NECESSITY versus SUFFICIENCY (cont'd)

- **National Security and Military Implications**
  - Striving to win individual battles without an understanding of how to win the war
    - » Vietnam for the U.S.
    - » Afghanistan for the Soviet Union
  - Must develop the astuteness to choose the right battles
    - » Tactics win battles
    - » The operational art wins the right battle and effectively follows up on the success
  - Grand strategy is the ability to choose the right war to fight
  - The emphasis on tactical lethality might not bring strategic success

Material & kinetic tactical means must be augmented with a broader regard for grand strategy

battle and effectively following up on that success). Especially worth noting, the industrial age preference for quantifiable measures of success is most applicable at the tactical level where the numerical net of enemy versus friendly losses is most synonymous with victory.

For two hundred years or so, the industrial age perspective has proven to be especially effective. And it has proven to be sufficient even at the operational and strategic levels (most notably the two World Wars) where the strategic circumstances afforded a close correlation between the friendly versus enemy loss ratios and ultimate victory. In these cases, the military's industrial-style emphasis on what was tactically necessary proved to be strategically sufficient for victory in war.

Since World War II, however, the record for industrial style emphasis on tactical lethality as being sufficient for strategic success has been mixed at best. Witness Vietnam, Afghanistan, the continuing problem posed by Iraq, and the still uncertain legacy in the Balkans-Kosovo campaign.

As we enter the new century, there seems to be a strong likelihood that the ability to accumulate a heavily favorable net ratio of enemy versus friendly losses, while necessary, will nevertheless not be sufficient. Although readily quantifiable, material/kinetic means of war at the tactical level will no doubt remain necessary, such capabilities promise to become less and less sufficient. There is a growing need for the basic tools of warfare to be augmented with an improved, broader regard for conflict at the level of grand strategy. This broader regard could in fact call into question not only the sufficiency, but also the necessity of the current suite of weapons and supporting capabilities that we have traditionally presumed to be both necessary and sufficient.

CLOSELY RELATED DISTINCTIONS

Efficiency versus Effectiveness; Quantitative versus Qualitative; (Adequacy of) Inputs versus Outputs; Knowledge versus Understanding (Insight and Wisdom); Systems versus Systems-of-Systems (Analyses); Training versus Education; Dexterity versus Creativity; Entity-focused versus Relationship-focused (Analytical Emphases).

QUANTITATIVE VERSUS QUALITATIVE

Industrial age thought tends to presume that productivity is achieved through predefined processes. These processes, once defined in terms of the kind of output products (added-value) that are presumed to be consistently desired, consume time, labor, and materials. The repetitive production procedures remain essentially regular and static until changed by a decision external to the process itself. Factors within such a regularized, static process are readily subject to quantification. Thus, the industrial cognitive style presumes that most any productive activity and the factors associated with it can somehow be quantified. This focus on quantification disposes the industrial age perspective to ignore issues having to do with qualitative change, especially change so profound as to produce discontinuity between previous experience and new circumstances.

Conversely, post-industrial thought tends not to presume the regularity of value-adding processes. This is because the kind of product desired to add value depends at any given time upon situational circumstances that rarely remain constant for very long. Thus, post-industrial thought, while not abandoning quantified analysis, tends to subordinate it to qualitative factors that contribute to a lack of stasis. These factors have to do primarily with situational relevance as affected by a potentially infinite spectrum of variables that interact with each other dynamically and often irregularly. (See Order vs. Chaos discussion.) Above all, post-industrial thought is careful not to define qualitative factors out of problem assessments simply because they do not lend themselves to currently available techniques of quantification.

Quantitative versus Qualitative

- **Industrial age thought tends to presume productivity is achieved in more or less set processes**
  - Production procedures are regular and static; quantifiable
- **Four primary assumptions of industrial mindset**
  - Value is assumed to be based on factors largely external to the production process
  - Assessment of the factors is assumed to be external to that process
  - Since it is not inherent to the continuous workings of the productive process, assessment of value need only be periodic
  - External factors that determine value (the free market, power relationships, etc.), while not truly static, change relatively slowly
- **Post-industrial thought tends not to presume the regularity of value-added processes**
  - Value-added product depends on situational circumstances
  - Does not abandon quantified analysis, but subordinates it to qualitative factors that contribute to a lack of stasis
  - Does not define qualitative factors out of problem assessments just because they do not lend themselves to available techniques of quantification

DISCUSSION

The most important factors in the differing industrial age and post-industrial regards for quantitative and qualitative factors have to do with how each viewpoint determines product value and, therefore how each assesses productivity. Comparison of the distinctive productive processes that result from these differing cognitive regards for value and productivity reveal much about each mindset. In August 2000 testimony before the Senate Banking Committee, Federal Reserve Chairman Alan Greenspan cited the continued inability of traditional methods of economic analysis and measurement to cope adequately with the value component of productivity in the "new (i.e., information-based) economy." Greenspan judged this to be the major source of today's uncertainty in gauging the nation's economic performance. This uncertainty extends well beyond just the economic sphere, to any process by which resources are specifically focused to produce valued results, including the national security/military sphere.

Three dominant assumptions infuse the highly quantified industrial mindset with regard to determination of value for any particular sort of product:

- Value (in terms of both absolute utility and the market for a product; or, for noncommercial productivity, situational relevance) is assumed to be determined by factors largely external to the productive process itself.
- Assessment of those factors also is, therefore, assumed to be external to that process.
- And, since it is not inherent to the continuous workings of the productive process, such assessment of value needs also only to be periodic, not continuous.

A fourth assumption inherent to the industrial way of thinking is that those external factors that determine value, i.e., the free market, extant power relationships, etc., while not truly static, possess a relatively slow rate of change. This is assumed, in turn, to permit application, with little or no adjustment, of the same set of planning assumptions over extended periods. The defining result is that, once determined, any given process presumes that its value relative to the external environment to continues indefinitely unless altered from the outside. Without such external intervention, it remains a self-referencing process.

Quantitative versus Qualitative (cont'd)

- **The post-industrial style tends to presume that the desired value of a productive process's output is not external and separate. Rather, it is inherent to that process**

- **National Security and Military Implications**
  - There is a risk of investing in assets that can be quantified, but are irrelevant to the new century's circumstances
  - Traditional measures of effectiveness (MOEs) are essentially tactical relationships that do not necessarily have positive strategic value in the new global security environment
  - Without qualitative examination of profound changes in the external environment, we may get a national security structure that is merely *efficiently ineffective*

In terms of value determination, the self-referencing focus of the classic industrial age mindset emphasizes one important internal determinant of value: the quality of the product that is achieved within the process. This is the primary "qualitative" focus of the industrial age mindset; but it is one that readily lends itself to quantitative assessment as, for example, in the "Quality Management" programs that are now ubiquitous throughout the industrial sectors of the economy. Assessment of overall productivity is quantitatively measured in terms of the amount produced and the number of defects detected, all as compared to how few resources were consumed.

The post-industrial cognitive style tends to presume that the determination of the desired value of a productive process's output is not external and separate, but inherent to that process. Nevertheless, the factors by which that determination is made are still largely external. Thus, the post-industrial determination of value, unlike its industrial counterpart, does not permit finite separation between internal and external perspectives.

The post-industrialization mindset also tends to presume that these external factors, while requiring continuous address within the productive process, will not be inclined toward regularity and stasis. Rather, they will incline strongly toward dynamism of such irregularity as to constitute (or at least approach) chaos. Further, even the factors that are most internally vital to the productive process's ability to handle such external irregularity and dynamism – creativity, insight, and, ultimately, wisdom – are also by nature irregular and dynamic. Thus, internal as well as external factors that decide value tend to resist quantification and, therefore, so does the entire post-industrial productive process.

NATIONAL SECURITY AND MILITARY IMPLICATIONS

The most basic implication of the foregoing discussion for national security and military concerns is the risk of investing in assets and processes that can be quantified but are not necessarily relevant to the new century's circumstances. In fact, they might be inappropriate – even counterproductive. Today's highly quantified measures of effectiveness (MOE) are direct reflections of the industrial mindset discussed above. They do not take into account the new circumstances that make today's global security environment so different from the body of experience from which they were derived.

More specifically, these MOEs focus exclusively on comparative attrition relationships. These are essentially tactical relationships that might not have positive strategic value in the newly evolving global security environment. Further, traditional MOEs implicitly incline analysis to acknowledge only certain kinds of issues and questions – mostly of an internal, self-referencing sort – and away from those that would require examining the qualitative implications of profound changes in the external environment.

Without such qualitative examination, we risk having a national security structure and military that would be, at best, efficiently ineffective. It will continue to suffer from the tendency to assume that tactical superiority is sufficient for strategic success. However, concerns about quantification notwithstanding, we obviously still need some objective reference basis for deciding the relative merits (including the economics) of particular assets and capabilities and concepts for employing them. The answer to this conundrum will most likely not be found in any sort of wholesale rejection of quantification. Rather, it will likely be achieved through development of new analytical techniques and factors of merit (FOM) for assessing strategic effectiveness. These new techniques would support quantification as one of several means for simultaneous, integrated understanding of strategic external effectiveness and tactical internal efficiencies and the means to achieve both.

CLOSELY RELATED DISTINCTIONS

Arithmetic vs. geometric; entities vs. relationships; efficient vs. effective; linear vs. nonlinear; price vs. value; material vs. intangible; necessity versus sufficiency; (adequacy of) input vs. (appropriateness of) output; specialization vs. holism; process-focused awareness vs. situation-focused awareness.

ARITHMETIC VERSUS GEOMETRIC RELATIONSHIPS

Industrial concepts and analyses tend to focus on direct, arithmetic comparisons. Post-industrial concepts and analyses, although accounting for arithmetic relationships, often become subordinate to a concern for largely indirect, geometric relationships. Such geometric relationships comprise a situational context in which certain arithmetic comparisons might or might not be logically valid. These differences in arithmetic versus geometric cognitive emphases result in practical differences between the industrial and post-industrial approaches to analysis and planning. The most basic of these differences is that the industrial, arithmetic focus is on measures of relatively static, physically- and materially-based strength, while the post-industrial, geometric emphasis is on power relevant to different situations.

DISCUSSION

An industrial, arithmetic perspective generally presumes, *a priori*, that a symmetry exists between or among various contexts (for example, opposing military force structures). Conversely, a post-industrial, geometric perspective first focuses on asymmetries between or among structures (forces) as an important context within which to determine what, if any, valid arithmetic relationships exist from which useful quantified comparisons can be made. Similarly, the industrial, arithmetic approach to comparative analysis tends to ignore external contextual (i.e., specific situational) factors that might make spurious even the most mathematically correct arithmetic comparisons (of, for example, lethal attrition rates). Conversely, the post-industrial, geometric approach to analysis precedes any arithmetic analytical comparisons with an explicit determination of the external context. It explicitly acknowledges such external considerations to be important shaping factors that determine the logical validity of any arithmetic comparisons (again, for example, between forces' lethal attrition capabilities) that might be argued to exist.

Arithmetic versus Geometric

- **Industrial concepts and analyses tend to focus on direct, arithmetic comparisons**
- **The industrial arithmetic focus is on measures of relatively static, physically- and materially-based strength**
- **Post-industrial concepts and analyses, although accounting for arithmetic relationships, often become subordinate to a concern for largely indirect, geometric relationships**
  - Such geometric relationships make up a situational context where certain arithmetic comparisons might or might not be logically valid
- **Post-industrial geometric emphasis is on power relevant to different situations**
- **National Security and Military Implications**
  - An industrial arithmetic perspective generally presumes *a priori*, the existence of a symmetry between or among various opposing military forces
  - Post-industrial geometric perspectives first focus on asymmetries between or among forces
    - » Then they determine which arithmetic relationships exist from which comparisons can be made

Further, in a specifically military context the industrial, arithmetic perspective will focus primarily on specific, fairly static and, thus, readily quantifiable characteristics of particular weapons and specific units (i.e., entities). This contrasts with the post-industrial, geometrically focused perspective that typically will emphasize dynamic (and therefore difficult to quantify) relationships that develop in certain situations between or among entities. (See separate essay on entities vs. relationships.)

The most important general difference between the industrial, arithmetic approach to analysis and planning and the post-industrial, geometric approach is this: The arithmetic approach is primarily concerned about doing things right, while the geometric approach focuses first and foremost on determining the right thing to do. (See also the separate treatment of efficiency vs. effectiveness.)

NATIONAL SECURITY AND MILITARY IMPLICATIONS

The post-industrial, geometric approach acknowledges and attempts to deal with at least two major (and closely related) categories of conceptual and analytical problems important to national security and military planners. These are the problems of (1) many-versus-many, and (2) asymmetry.

Conflict scenarios in which a single entity (i.e., a weapons platform or individual unit) fights head-to-head against another individual entity, or even against several opposing entities, occur very rarely. Most would agree that they seem likely be even rarer in the future. Likely even more rare will be situations in which single units will be facing opposition that is symmetrical in organization and equipment, much less in operational doctrine and tactics.

More typical of the "real world" are highly dynamic encounters involving several different kinds of units and numerous types of weapons, often even with numerous sides to a conflict. In addition to their many-versus-many aspects, these situations involve considerable asymmetry in not just weapons, organizational structures, doctrine, and tactics, but with great variances between the basic strategic objectives.

Stark, generally static arithmetic comparisons of individual weapon and unit capacities to inflict attrition on similar forces hold little relevance for meaningful assessment of asymmetric encounters. Outcomes of such situations are

Arithmetic versus Geometric (cont'd)

National Security and Military Implications (cont'd)

- The post-industrial geometric approach attempts to deal with conceptual and analytical problems of force-on-force and asymmetry
- The arithmetic approach:
  - » Resulted in failure to understand the SCUD's real importance in the Gulf War
  - » Led to poor evaluation of B-52 Arc Light missions in Vietnam

The arithmetic approach is primarily concerned with doing things right, while the geometric approach focuses first and foremost on determining the right thing to do.

determined much more by factors that evolve, ebb, and flow than by the readily quantifiable lethal capacities of the weapons and units involved.

Two examples will suffice here. The first is from the 1990 Gulf War. During the American buildup of forces in the Gulf and the painstakingly developed concept for their eventual combat employment, scant attention was paid to the Iraqi SCUD missile threat. The arithmetically correct assessment of the SCUD was that it was a weapon whose lack of substantial throw-weight, range, and operational reliability all combined to limit its lethal potential to a point of near irrelevance. However, as the Gulf War evolved, the arithmetically unimpressive SCUD exerted a tremendous shaping – i.e., geometric – force upon the entire conflict. The quantitatively puny tactical potential of the SCUD achieved a strategic effect that forced the U.S. to substantially re-prioritize not only its air war, but even its logistics efforts to mitigate the psychological effect of the SCUD threat on the coalition alliance, the political cohesion of which was vital to the campaign at the strategic and policy levels. The cumbersome and complex Patriot air defense missile system had to be brought *ad hoc* into the theater at the considerable diversion of otherwise needed airlift – all in an attempt essentially to counter the non-material, but disproportionately powerful, political effects of an outmoded weapon system.

The second example goes back to the Vietnam War, and concerns the B-52 ARCLIGHT bombing effort. ARCLIGHT was directed against North Vietnamese and Viet Cong tactical and logistics units and operations. Needless to say, like the entire Vietnam War, the ARCLIGHT bombing program was highly controversial at home. As such, it was the continuous target of motivated reviews intended to determine its "effectiveness." The industrial, arithmetic mindset characteristic of the McNamara Department of Defense (and from which today's emphases on quantification evolved) focused on the attrition effects against the enemy that the ARCLIGHT program was supposed to be achieving.

In fact, these attrition effects were based upon highly questionable reporting of enemy "killed-by-air" figures from U.S. and allied operational units and even from thousands of unverifiable interrogation reports taken from enemy prisoners. The enormous analytical efforts both on behalf of and against ARCLIGHT all paid scant attention to the important and even intuitively obvious – but impossible to quantify – shaping (i.e., geometric) effect of ARCLIGHT. This was the bombing program's effect in limiting the enemy's options for mounting

very large-scale fire and maneuver operations, thus denying him much capacity for initiative.

With a few admitted exceptions (the 1968 Tet Offensive being the most notorious), this significant shaping effect of ARCLIGHT continued until it was curtailed (again for domestic political reasons) well toward the end of the conflict. However, by focusing chiefly on arithmetic factors (i.e., ARCLIGHT's record of lethality), the U.S. failed to capitalize on an obviously important factor. The industrial mindset of the day focused on the number of enemy that ARCLIGHT had killed. A post-industrial perspective rooted in a primary concern for geometric shaping effects would have evaluated ARCLIGHT in terms of how well it forced the enemy into patterns of undesired operational activity.

It is almost certain that today an industrial, essentially arithmetic cognitive style continues to dominate American strategic thinking.

CLOSELY RELATED DISTINCTIONS

Quantitative vs. Qualitative; Entity vs. Relationship (Analytical Focuses); Efficiency vs. Effectiveness; Linear vs. Nonlinear; Price vs. Value; Knowledge vs. Understanding, Insight, and Wisdom; Training vs. Education; Dexterity vs. Creativity.

DEXTERITY VERSUS CREATIVITY

As used here, dexterity is the ability to perform given tasks or processes efficiently. Conversely, creativity is the process by which those tasks and processes are first conceived and defined and then continuously amended to suit changing circumstances.

DISCUSSION

Industrial thinking emphasizes finite definition of special processes and the specialist skills and structures by and within which they are performed. The industrial organization of work presumes that the value-added contributions to the production of wealth – or in the government/military sector, to national well-being and security – made by most workers and work organizations will be through dexterity in their performance of defined processes and skills within a specifically defined organizational structure. The definition of the work implicitly assumes that efficiency in its performance equates to effectiveness in some larger sense. Such individual and group dexterity comes about through training and practice. It is enhanced by continuity of both workers and the prescribed processes of their work; it is most threatened by change in both the composition of the workforce (turnover) and/or the work processes and organizational structure. In this (the classic industrial) model, the creativity function is closely monitored and controlled. Creativity is, in fact, dominated by persons in the senior echelons of the organizational hierarchy.

The post-industrial model does not reject dexterity; rather, it expects more from it. Individual workers and organizations must, of course, still perform processes with skillful efficiency. But the processes themselves – and the structures through which they are performed – must be dynamically adaptable to broadly and rapidly changing external circumstances. This process of change depends upon creativity, especially by those who are doing the work. This imperative for creativity stands generally in opposition to concerns for well defined hierarchical relationships, structure, and process. It cannot be cultivated merely through training. It is the product of both innate intellectual ability and education. (See the separate essay on training versus education.)

The post-industrial reality is that, especially as machines take over more and more of the (essentially rule-based) dexterity functions, proportionately more workers will be required to make their value-added contributions through

Dexterity versus Creativity

- **Dexterity is the ability to perform efficiently within predetermined tasks or processes**
- **Creativity is the process of first conceiving and defining those tasks**
- **Industrial organization presumes that value-added contributions to the production of wealth will be made through dexterity in their performance of certain processes and skills within a specifically defined organizational structure**
- **The post-industrial model does not reject dexterity … it expects more from it**
  - The processes themselves must be dynamically adaptable to broadly and rapidly changing external circumstances
  - The process of change depends on creativity, especially from those doing the work
  - The imperative for change stands in opposition to concerns for stability
  - It is the product of both innate intellectual ability and education

increased creativity. However, it goes without saying that the intellectual demands of creativity and education are greater than for dexterity and training.

It seems likely that proportionally fewer people will be able to perform in post-industrial approximations of earlier industrially-defined work positions. Rewards will continue to shrink for those who can only work "inside the box"; they will grow disproportionately for those who can create – as well as then work within – "new boxes." Schemes for organizing work in the future therefore face twin challenges of how to fill increasingly demanding positions, and then what to do with the growing number of people who cannot perform as well relative to the new demands for creativity. The dexterity vs. creativity distinction also presents a troubling challenge to today's dominant political and social sensitivities by implying a stark competition based on merit and accomplishment for workers. Many will fear that such competition will abet elitism within the society.

NATIONAL SECURITY AND MILITARY IMPLICATIONS

In classic industrial age combat, the typical soldier was expected to perform with dexterity a fairly finite set of tasks that involved skills for which he could be readily trained. These tasks and skills were defined within a general strategic and political appreciation of the military's overriding purpose as simply being capable of closing with and destroying an enemy force. Today, in the age of globalization (a phenomenon directly associated with post-industrialization) the military must still be able to close with and destroy the enemy, but it is also expected to do a broader range of things. Common to all of these new missions (the most important of which are peacemaking and peacekeeping) is the need to cope with highly dynamic external situations and the associated need for keen judgment on the part of even very junior personnel. This is especially true as technology permits junior people to preside over degrees of lethality that previously were reserved under the personal control of more experienced officers and NCOs.

Dexterity versus Creativity (cont'd)

- **Organizing work for the future faces two challenges**
  - How to fill increasingly demanding positions
  - What to do with the growing number of people who cannot perform well relative to the new demands for creativity
- **National Security and Military Implications**
  - In classical industrial age combat, the typical soldier was expected to perform with dexterity a fairly definite set of tasks using skills for which he had been trained
  - Today, the post-industrial soldier must still be able to close with the enemy, but he must also
    - » Cope with highly dynamic external situations
    - » Be able to use keen judgment (even very junior personnel)

CLOSELY RELATED DISTINCTIONS

Necessary vs. sufficient; training vs. education; specialization vs. holism; knowledge vs. understanding (permitting insight and judgment); efficiency vs. effectiveness; codifiable vs. non-codifiable; regular vs. non-regular; linear vs. nonlinear; authoritative vs. participatory; hierarchical vs. diffused.

TRAINING VERSUS EDUCATION

In its concern for the intellectual preparation of individuals and organizations for productive work, industrial age thinking tends to emphasize specific, task- and skill-oriented training over more generally focused education. In fact, the industrial perspective tends to avoid clear distinctions between training and education. It is more comfortable with training regimens than with true education because the former are more readily auditable to determine returns on investment.

Conversely, the post-industrial intellectual approach tends to recognize job- and task-specific training as a follow-on to broadly focused education. It sees education as an enabler of individuals to absorb successive waves of task-specific training as technology and its effects transform work and the economy.

In its most basic sense, training teaches how to perform tasks that have been conceived and structured by others. Education, on the other hand, teaches how to think, and thereby how to learn. Rapidly evolving technology increasingly obviates a particular training course. Thus, as training becomes ever more important as the key to keeping pace with technology, it also becomes more perishable.

DISCUSSION

The perishability of training is why the post-industrial economy places a premium on the ability of individuals and their organizations to continuously learn and adapt. Only a firm educational base can provide that ability. The ideal outcome of training is dexterity in a predefined skill or set of skills. The ideal outcomes of education are (1) a deeply based, broadly receptive ability to learn, and (2) the enabling of capacities for creativity. Therefore,

- *The more a set of designated job responsibilities depends on readily definable criteria of dexterity achievable through training, the more likely the tasks associated with those responsibilities are to be eventually accomplished by a computer.*
- *The more dependent a job's responsibilities are open-ended in the functions and tasks they imply, the more they presume education, and the less likely they are to be computerized.*

Before training-based tasks are fully taken over by computers, they are likely in the interim to be the focus of cutthroat low-wage rate competition. This competition, already evident around the world, is characterized both by global economic immigration (legal and illegal) of low-wage

Training versus Education

- **Industrial age thinking emphasizes specific, task/skill-oriented training over more generally focused education**
  - Tends to avoid clear distinctions between training and education
- **Post-industrial approach tends to recognize the training versus education distinction and to see job/task-specific training as a follow-on to broadly focused education**
  - Sees education as vital general enabler of individuals and organizations absorbing successive waves of task-specific training as technology and its effects transform work and the economy
- **Training is perishable in the post-industrial socio-economy**
  - Emphasis is to place a premium on ability of individuals and organizations to continuously learn and adapt to changing technologies and the changing economic and employment conditions

workers into high-wage labor markets, as well as by the migration of jobs to low-wage – but increasingly trained and trainable – overseas labor forces. In mirror image fashion, jobs that require a truly educated, open-ended capacity to learn, analyze, problem solve, and create tend increasingly to concentrate in the upper socio-economic echelons of societies. In the longer term, these jobs and those capable of holding them might concentrate not just in the upper echelons of attractive socio-economies (especially America), but eventually in the world's most desirable and secure geographic and climatological settings.

As observed in the essay on dexterity vs. creativity, it is likely that more individuals in a given population are capable of succeeding in training than are capable of contributing truly productive creativity. A similar likelihood applies regarding training vs. education. Many more individuals (as well as their teachers) are likely to succeed in a well-defined training context than would succeed in a much more open-ended educational context. Thus, more or less in lockstep with the distinction between dexterity and creativity, that between training and education carries with it a host of political, economic, and psycho-social challenges, all of them unavoidably tinged by the emotionally and politically charged allegation of elitism.

NATIONAL SECURITY AND MILITARY IMPLICATIONS

A professional military force such as that of the United States will ultimately reflect the stresses within the society from which it is drawn. Therefore, it is not unreasonable to expect that within the coming decade the U.S. military will have to take into account and somehow cope with the elitist vs. egalitarian stresses at the heart of the dexterity-versus-creativity and training-versus-education dilemmas.

In addition to the obvious morale, compensation, and organizational psychology implications that elitist tendencies typically hold for military esprit, these particular issues carry with them practical conceptual and structural implications.

The modern military, like other institutions intellectually rooted in the industrial mindset, has tended to avoid acknowledging hard and fast distinctions between training and education. Professional educational institutions within the services (i.e., the staff and war colleges) are regularly threatened with losing their independent status and being subordinated to the larger training apparatus. (In fact, this is the current arrangement within the U.S. Air Force.) Because the educational return-on-investment defies explicit audit, congressional and Executive Branch fiscal managers

Training versus Education (cont'd)

- **National Security and Military Implications**
  - A professional military will, at least to some degree, reflect the stresses of its national society
  - The U.S. military will have to take into account and cope with the elitist versus egalitarian stresses at the heart of two dilemmas
    - » Dexterity versus creativity
    - » Training versus education
  - The modern military has tended to avoid acknowledging hard and fast distinctions between training and education
    - » PME is often subordinated to the larger training apparatus
    - » Officers are not given the time to learn about and reflect on the moral demands of warfare and decision making, and for penalty-free experimentation
  - Questions:
    - » How do we accommodate the need to provide education and training appropriate to post-industrial realities?
    - » How do we meld that training with the need to assess and sharpen an individual's judgment?
    - » How do we develop appropriate means for assessing what to teach and how to teach it?

tend to press Department of Defense educational institutions for the "relevance" of their curricula to current military concepts and force structure.

It is not at all surprising that even the officer students attending professional military education express frustration with curricula that seem to be long on general background and short on readily usable information suitable for practical application in their next assignment. Their frustration reflects the industrial mindset's assumption that observable (i.e., auditable) activity is directly related to valuable production. Even more directly, their impatience also reflects a corollary institutional tendency to consider that time spent not in action but in reflection is less than productive. Now, a decade after the end of the Cold War, it is perhaps useful to look back upon the period between the World Wars, a time of watershed peacetime change in military affairs preceding our own. It was also a period when the military was more removed economically and socially from the American mainstream, and thus not nearly so industrialized in its intellectual style as it subsequently became. With few overseas troop commitments and with only a very small enlisted force to oversee, officers of the 1920s and '30s were afforded (and expected to use) time to read and reflect and to discuss among themselves the implications of rapidly changing technology and world circumstances. For example, company commanders were routinely expected to host reading seminars at their quarters for their lieutenants, often during duty hours.

The same institutional attitude also tolerated experimentation as well as error-prone, loosely scripted exercises, all on a relatively penalty-free basis. Worth noting also, the military's appreciation for an educated intellectual base was reflected in its own particular regard for education and the means to achieve it. The military did not attempt to seek to accredit its educational efforts within the civilian educational structure.

As it turned out, this two decade period of rumination provided the military and the nation with a vital reservoir of intellectual rigor and understanding without which the rapid planning and force expansion to fight and win World War II likely would have failed. Given the frenetic operational tempo that current American policy imposes upon today's military, the present does not compare well with the interwar decades in terms of encouragement of personal and organizational intellectual rumination and penalty free experimentation.

The root of this problem goes well beyond the issue of operational tempo to a deeper issue of current military culture.

Today's military seems to have acculturated attitudes that are so biased toward action and away from reflection that the institution is not inclined even to find time that might in fact still be available for meaningful, penalty free and unauditable reflection.

This is evident even in the military's institutions that are explicitly dedicated to education. Because of Congressional pressures for more "rigor" (read "auditability"), the staff and war colleges over the past decade have adopted curricula that increasingly stress evaluation and credentials (award of civilian master's degrees). While the concept of intellectual rigor is always to be applauded, there arises with it the danger that the specific arrangements for achieving that rigor will be spurious (or, worse, counterproductive). In the current context, one should question whether the civilian focus on academic credentials is appropriate to the military environment. Do the hours spent by middle-grade officers reacquainting themselves with and accommodating the research and documentation techniques peculiar to strictly academic institutions count for the sort of educational rigor appropriate for senior military responsibility? The current situation seems to require especially close consideration of whether currently endorsed measures of educational rigor actually equate to measures of military appropriateness and effectiveness. This is especially important when considered against the sorts of sophisticated judgments (including difficult moral judgments) that senior officers are likely to require in the future.

Perhaps even more vexing than the question of the appropriate content of professional military education is the question of its timing in the course of an officer's career. This should be of particular concern today, since the American civilian educational structure has come to reflect nearly directly the post-industrial mindset's ambivalence towards differences in purpose and method between training and education. Today's officer typically comes from a civilian four-year college and possesses an undergraduate degree in a specific and, more often than not, fairly technical discipline. While successful completion of the degree requirement certainly attests to a newly minted officer's generally desirable qualities as a person, it cannot be assumed that his or her degree program provided an educational base for lifelong learning.

The officer's degree could, in fact, merely document a curriculum that involved considerably more training than it did education. Waiting thirteen or eighteen years into an officer's career before providing a truly educational experience would

seem ill advised. Those who come into the service having only been trained seem certain to need some sort of valid education experience early in their careers to provide them the basis for continued learning. The need to assess the particular educational qualities that a new officer's civilian academic credentials actually bespeak as a basis for continued learning is, of course, a daunting challenge, both intellectually and politically. How to assess the specific requirements for an in-service regimen for educational preparation, and how to structure it, are the keys to resolving the issue.

Issues surrounding military training generally run closer to civilian experience than do those of professional military education. Better than ninety percent of enlisted specialties now consist of skills fairly closely equivalent to those in the civilian economy. This raises the question of which military support functions actually require military individuals to perform them, and which might in fact be accomplished better with civilians, whether government or contractor employees. One appropriate criterion for making this distinction, and, therefore, for deciding which specialties will continue to require military-specific training, might be based on the following question: How much and what kinds of judgment of a specific military nature will the trainee's prospective specialist duties require?

Just as the post-industrial civilian job environment is placing an ever greater premium on job skills that require capacities for judgment, so it must be expected that military duties will similarly come to emphasize the need for individuals to render sophisticated judgments. The unavoidable vagaries of today's peacemaking and peacekeeping operations around the world have already underscored how the combat arms have changed in their elevated expectations for even the most junior of their ranks to make sophisticated judgments.

As is the case in the civilian labor market, the military environment promises to provide fewer and fewer positions for persons who are only able – or only willing – to be "trained" in the classic sense of the word. In both the civilian and the military settings, a person's capacity to develop and adapt his or her dexterity through nearly continuous retraining not only will be demanded, it will be presumed. The real discriminators among jobs and among those who fill them will be a job's requirements for individual problem solving initiative and creativity and, probably above all, judgment.

These requirements raise several difficult and sensitive issues. For example, how to effectively accommodate the need to provide training appropriate to post-industrial realities; how, in particular, to meld that training with the need to hone and assess individual's judgment. These questions and others associated with them are likely to present the military of the future with a set of challenges at least as severe as those mentioned above in regard to professional military education. And, as in the case of PME, at the heart of those challenges will be the one of developing appropriate means for assessing what to teach and how to teach it.

CLOSELY RELATED DISTINCTIONS

Dexterity vs. Creativity; Efficiency vs. Effectiveness; Knowledge vs. Understanding (and Insight and Wisdom); Arithmetic vs. Geometric; Entities vs. Relationships (as analytical focuses); Strength vs. Power.

ADEQUATE INPUT VERSUS APPROPRIATE OUTPUT

Classic industrial age economic precepts rely heavily on assumptions that directly link resource inputs to produce value-added output. Inputs are regarded essentially in terms of costs incurred; outputs are regarded in terms of price achieved. In both cases, price is generally assumed to directly reflect value.

Post-industrial experience challenges such linear assumptions about the relationship of quantitatively measurable resource inputs. The relationship seems increasingly nonlinear for the most rapidly growing sectors of the economy, i.e., those most closely associated with the information revolution. (See separate essay on linear vs. nonlinear.)

DISCUSSION

The industrial-age organizational model typically uses value output as a basis for defining relationships between and among organizational entities. It uses resource input as a basis for defining structure and processes within those entities. For example, companies that make several different kinds of products are typically divided organizationally by the products they produce. A plastics company might be arranged into the floor coverings division, the food container division, industrial packaging division, etc. But within each of those divisions, the organizational structure is most likely to be defined in terms of the various resource inputs from which the outputs are processed.

In large organizations and institutions (primarily public and nonprofit institutions, especially government) where no readily quantifiable value-added product can be discerned as output, the tendency is to organize at ever higher levels around the management of generally defined services. Thus it is, for example, that although the military is responsible for national security and victory in war as value outputs, it is organized basically by the differing kinds of resources that comprise it.

As practically necessary as this organizational approach might be, the industrial age focus on organization around specific inputs has trouble accommodating post-industrial production relationships. It assumes that separately managed resources will produce appropriate output results. Post-industrialization undermines this logic as a result of three seemingly opposing tendencies that are inherent to post-

Adequate Input versus Appropriate Output

- **Industrial age precepts rely heavily on directly linking resource inputs quantitatively to produced value output**
  - Inputs are regarded in terms of costs incurred; outputs in terms of price achieved
- **Post-industrial thinking challenges such linear assumptions**
  - It considers input/output relationships to be increasingly non-linear for the most rapidly growing sectors of the economy
- **Post-industrialization undermines past input/output logic in three ways**
  - Information is coming to dominate all other inputs as a measure of value and competitive outcomes
  - Information is itself an input category too general to be a specific dimension around which to organize
  - Information is too varied in form and dynamic in content to allow easy organizational distinctions to be made and maintained

industrialization. The first is that information (to include the technologies that produce, process, and communicate it) is coming to dominate all other inputs as a measure of value (and therefore also of competitive outcomes, whether economic or military or of most any other dimension). Second, information is itself an input category too enormous and general to constitute a specific dimension around which to organize. Third, information is too varied in form and dynamic in content to permit easy organizational distinctions to be made and maintained on a practical basis. (As quintessential "information organizations," intelligence organizations have, for example, always struggled with these challenges as they have continuously reorganized themselves, going repeatedly back and forth among geographic-specific, function-specific, technology-specific, and (analytical) "problem-specific" organizational structures. Their frustrating experience seems likely to become ever more generalized within the 21st century's socio-economy.)

NATIONAL SECURITY AND MILITARY IMPLICATIONS

Traditional military organizational arrangements tend to emphasize the distinctive contributions (inputs) of highly differentiated material resources over the general contributions of much less differentiable inputs contributed by information resources. In fact, today's overall national security structure, including the military and the several other agencies and organizations it encompasses, is organized almost exclusively in terms of differentiated inputs to national security as opposed to being organized by different sorts of needed results, depending on circumstances. (This applies even to the geographically organized (differentiated) unified commands which, immediately below their unified headquarters, comprise separately organized commands manned and equipped by each of the three different armed service departments.) Such a traditional approach to military organization may very well encounter increasing difficulty in producing outputs that are appropriate to the highly fluid and dynamic situations that seem most likely to characterize the 21st Century global security environment.

Just as is the case in the post-industrial, socio-economy generally, technological advances in the military sphere – most generally information and information-dependent technologies – are blurring the organizational significance of distinctions among different categories of resource inputs as they are combined to achieve outcomes (outputs). For example, technology increasingly permits both armies and navies to be

Adequate Input versus Appropriate Output (cont'd)

- **National Security and Military Implications**
  - Today's security structure is formed almost entirely in terms of differentiated inputs as opposed to organization for needed results
  - In our competitive funding system, this increasing arbitrariness of organizing promises to be a source of confused logic and political rancor
  - A theoretically possible solution might be to reorganize forces in terms of objective to be achieved
    - » Victory in major wars
    - » Prevailing in lesser conflicts
    - » Peace making and peace keeping
    - » Control of drug trafficking, weapons proliferation, and illegal immigration

capable of seizing the strategic initiative from enemies at ever longer range. Similarly, air forces are becoming increasingly capable of the close precision traditionally associated with surface forces. These changes mean that the traditional logic by which military forces are organized and differentiated according to geospatial location and the medium from which they fire/launch their weapons is becoming increasingly arbitrary as a concept for focusing capabilities.

In a competitive funding system such as ours, this increasing arbitrariness of organizing principles promises to be a growing source of confused logic and political rancor. A theoretically possible solution might be to reorganize forces in terms of the different categories of objectives (outputs) that need to be achieved. Possible examples of such "outputs" might be victory in large wars; prevailing satisfactorily in lesser contingencies; peace keeping/peace making; achieving and maintaining police-like control of endemic global problems such as drug trafficking, weapons proliferation, illicit immigration, etc. Each kind of objective would have its own organizational mix of capabilities. (This is not necessarily to say that the same resources could not be variously assignable simultaneously to two or more of these outcome-defined structures. However, it must also be acknowledged that such multi-role possibilities would be limited by training, geographic basing constraints, and other practical considerations.)

The likely impact on the military of such a reshuffling in terms of obviated traditional institutional identifications, and therefore esprit, cannot be understated. Nevertheless, good policy will be well served by insight into the ways and extent to which post-industrial realities continue to weaken the traditional logic of organizing the military by type of resource input.

CLOSELY RELATED DISTINCTIONS

Specialization vs. holism; efficiency vs. effectiveness; hierarchical vs. diffused; linear vs. nonlinear; arithmetic vs. geometric; discrete vs. integrated; strategic planning vs. strategic thinking; (organizational emphasis on) entities vs. relationships; "systems" vs. "systems of systems of systems; "process focus vs. situation focus; imposing order vs. accepting chaos (as an operating condition).

EFFICIENCY VERSUS EFFECTIVENESS

As discussed in other essays in this series, the industrial age mindset tends to default toward quantified over qualitative factors, inputs into a process over outputs from it, arithmetic over geometric relationships, and linearity over non-linearity in its implicit expectations about the future. These interrelated tendencies comprise an internally focused, self-referential regard for systems and processes. This focus tends, in turn, to presume a close alignment between internal efficiency and effectiveness relative to the external environment. Conversely, the post-industrial perspective, while retaining concerns for internal efficiency, continuously maintains an explicit, external focus on effectiveness relative to the changing environment. That is to say, the post-industrial perspective presumes no enduring relationship to exist between internal efficiency and the effects it might or might not exercise on the external context. (See also the essay on necessary vs. sufficient.)

DISCUSSION

The industrial age perspective tends to confine its examination of a structure's, system's, or process's produced effects on the external context not as a matter of continuous, internalized routine but only as an explicit effort separate from the normal routine. On the other hand, the post-industrial mindset, while not at all abandoning the concerns of the industrial perspective for efficiency, implicitly maintains an overriding focus on changes to the external environment that might require changes to internal factors. This may go so far as the acceptance of what established internal norms would consider inefficiencies to achieve effectiveness against changed external circumstances.

As a result of its nearly synonymous regard for efficiency and effectiveness, the classic industrial analytical perspective has trouble in acknowledging the risk of becoming efficiently ineffective as external circumstances change. Similarly, it has trouble in perceiving that a particular set of assumptions about what constitutes progress might lose its validity.

Efficiency versus Effectiveness

- **Efficiency emphasizes cost; effectiveness emphasizes results**
  - World War II was pursued for effectiveness; before and after World War II, efficiency ruled and costs governed
- **Efficiency versus effectiveness issues are not new to the post-industrial age**
  - Industrial enterprises have ignored them with disastrous effects
    - » Many were internally efficient but failed to recognize external changes
  - Steam locomotive manufacturers versus diesel-electric power designs
  - Swiss watch industry versus integrated circuits
  - Mainframe computer industry versus PC-based, network applications
- **Industrial analysis has trouble acknowledging the risk of becoming efficiently ineffective as external circumstances change**

Efficiency vs. effectiveness and the other cognitive distinctions discussed in these essays are of course not new concerns peculiar to the post-industrial age. They have always been important to logical thought. Not infrequently during the industrial age, industrial enterprises ignored these distinctions with disastrous effects as they failed to recognize and accommodate changing external conditions. Examples of such failures can be found both in America and elsewhere in the world. The only difference between the circumstances of these examples and those of today is that cognitive challenges such as these are inherent to the new epoch rather than, as in the industrial age, being anomalous to it.

An example of such a cognitive challenge comes from American railroad history. From the 1830s to the early 1900s, American railroading technology, particularly steam locomotion, made enormous strides in the speeds and tractive power with which it could move goods and people. Within a lifetime, the technology moved from rickety locomotives that lost races to horses to engines that regularly approached better than seventy miles an hour. Only a few years later, still well within a century of railroading's beginnings, crack trains were capable of speeds exceeding a hundred miles per hour, all still with steam locomotion.

This progress was largely the result of highly focused engineering expertise being applied over decades to achieve ever increasing internal efficiencies within steam engines, combined with the builders' ability to convert the resulting increased force into tractive power. Production of steam locomotives became the first heavy industry in which the United States led the world. However, the American success with steam locomotive technology and the industry's unexamined association of progress with improved internal efficiencies of steam laid a base of certain implicit assumptions that would eventually prove fatal to the industry.

Chief among these assumptions was that the industry's central business was steam locomotion, rather than locomotion generally. Thus it was that as late as the 1940s the largest locomotive producers in the country – Lima, Baldwin and the Pennsylvania Railroad's famed Altoona Works – saw the future of railroad traction to rest in aerodynamic streamlining of steam engines and not in diesel-electric technology. This despite the fact that the advantages of diesel-electric power had been known since at least the mid-1930s.

Internal focus on self-referencing efficiencies prevented the industry's leaders from developing a comprehensive perspective of the outside world, most notably of their prime

Efficiency versus Effectiveness (cont'd)

- **National Security and Military Implications**
  - The American military evolved during the heyday of the industrial age; it has an industrial age mindset
  - Today's military is apt to do and buy things more for their amenability to traditionally quantifiable analyses rather than for relevance to the rapidly altering external circumstances and threats to the nation
  - Germany's greater military effectiveness in 1940 came about because the Germans combined advanced, but generally available, military technologies into a new geometry of warfare
  - British and French armies that used new technologies within old operational and organization concepts were crushed by Germany's ability to use existing efficiencies effectively
- **Failing to regard and examine conflict from new perspectives and in new dimensions will give us a military capable of doing the wrong (or spurious) things well**

customer base, America's long-haul railroads. The locomotive builders failed to appreciate that the locomotive was merely a system within a larger system that was subject to considerable change over time. Unable to develop until too late such an outward looking, system-of-systems understanding of their customers' business, leaders of the steam locomotive industry were both initially unable and later unwilling to acknowledge the far-reaching advantages that diesel-electric traction offered American railroads.

Even when finally realizing the startling economies afforded railroads by diesel-electric's less cumbersome fueling and maintenance requirements, and above all else the reduced damage to tracks and roadbeds that diesel-electrics inflicted, these same leaders rationalized that these economies were competitively offset by steam's readily documented capacity to deliver still greater maximum tractive power as compared to diesel-electric.

The practical effect of this lack of differentiation between efficiency and effectiveness was that, within little more than a decade following World War II – the high water mark of American steam railroading – the erstwhile leading names in railroad traction technology suffered dramatically. By then they were either out of business or so restructured as to be practically unrecognizable to their leaders and workers of only a few years earlier.

Similar examples come from well outside heavy industry. Especially notable is the Swiss watch industry's failure, beginning in the late 1960s, to fathom the implications of integrated circuit technology. For centuries, Swiss timepiece makers had directly and unquestioningly equated the increased accuracy that they achieved over the years in mechanical watch and clock movement with industry effectiveness. In fact, the entire industry – and therefore much of the Swiss national economy – was organized around assumptions about profitability, organization markets, and management-to-employee relations that flowed from this most fundamental assumption about the relationship of efficiency to effectiveness. The resulting self-referencing, internal perspective that characterized the Swiss timepiece industry precluded it from understanding the transforming power that a technology such as integrated electronic circuitry – so orthogonal to their own technological and business experience – would bring to the worldwide competitive environment. Now, thirty years later, the Swiss timepiece industry's adjustment and that of some Swiss regional economies, while dramatic, are still not entirely accomplished.

Still another example from within the computer industry, which is itself at the heart of the industrial to post-industrial transformation, concerns the ironic failure of the mainframe segment of the industry to appreciate the cascading implications of improving integrated circuit technology. In particular, the mainframe manufacturers failed to appreciate the implications of ever improving integrated circuit capacities to deliver more and more computing power in smaller and smaller packages.

The mainframe industry came to focus on its own improving capabilities to achieve enormous computing capacities (i.e., essentially efficiencies of a sort). While doing so, it failed to appreciate adequately the potential effectiveness (e.g., marketability, flexibility of application, potential for distributed processing) of lesser processing capacities. In particular, it failed to see the potential combined effectiveness of small, modestly capable computers when incorporated in very small, cheap, user-friendly units connected through local area networks and the Internet. Wrenching industrial realignment resulted from this lack of vision in differentiating self-referencing mainframe processing efficiencies from externally relevant effectiveness achievable by smaller computers working together on a system-of-systems basis. The effects of this shortsightedness remains with us today in the tumult of change that continues to characterize the computer industry and the markets it serves.

NATIONAL SECURITY AND MILITARY IMPLICATIONS

As an institution whose current intellectual style evolved in the heyday of the industrial age, the mindset of today's American military shares with other industrial age organizations a nearly synonymous regard for efficiency as compared to effectiveness. In particular, measures of merit (MOM) for practical evaluations of personnel, units, equipment, and procedures are based much more upon circumstances within the institution than upon circumstances external to it. Thus, the leadership and management structures of the MOM are more likely to note and deal with changes within the institution than they are to react decisively to changes external to it. Therefore, changes that are made within the institution are considerably more likely to be driven by internal considerations than by changes to the external environment.

The resulting risk of all this is that of the entire institution becoming efficiently ineffective. The spurious

equating of internal efficiency with actual effectiveness can preclude for the military an adequate vision of its relationship with the outside world. Lacking such a vision, neither the military nor any other institution can recognize changes in the external environment that are orthogonal (i.e., asymmetric, nonlinear) to the logic of its internal workings.

This lack of externally focused vision leads inevitably to priorities in expected performance and planned investments that are likely to reflect more relevance to the institution's internal conditions than they do to external realities. Given the industrial mindset's keen regard for quantification, today's military is apt to do and buy things more for their amenability to traditionally quantifiable analytical techniques than for their actual relevance to the rapidly altering external circumstances and threats to the nation.

Fully a decade since the end of the Cold War, the inception of every one of the U.S. Armed Service departments' current top acquisition priorities can be traced in the logic of its relevance to the external environment assumptions that were inherent to the Cold War. To the extent that the services have at all adjusted these programs to reflect the changed post-Cold War external environment, it is that the externally focused arguments for these programs have changed, much more so than have the programs themselves.

In some important ways, these programs are not unlike the long disappeared steam locomotive industry. They tend uncritically to presume that the sorts of improved capabilities they would provide remain as relevant for today and tomorrow as they would have been for the Cold War environment for which they were originally conceived.

When adding in lifetime operational costs, investments in programs such as the F-22, Joint Strike Fighter, follow-on to the *Nimitz* aircraft carrier, the Crusader Advanced Artillery System, etc., would total potentially to well more than a trillion dollars. Thus, these programs are likely to dictate the character and capabilities of the US military for three to five decades into the future. That prospect cannot help but call to mind the specter of the steam locomotive industry's faith in the relevance to the future of "streamlined steam engines."

Even closer as a metaphorical warning to today's military is the classic comparison of Germany's greater military effectiveness compared to the West at the beginning of World War II. Although probably not as consciously as it seems in retrospect, the Germans combined advanced – but generally available – military technologies (e.g., monoplane

aircraft, tanks, ground-to-ground and air-to-surface wireless communications) into a new geometry of warfare.

This new German military geometry embodied a kind of effectiveness that obviated whatever arithmetic efficiencies the less visionary Western allies could achieve, even with their greater numbers of more technologically impressive equipment. The Western allies generally regarded these new technologies essentially as ways to do better what they had already been doing for decades. For example, French tanks were assigned almost exclusively within infantry units to give fire support and moving cover to infantry advancing on foot, thus squandering the tank's potential for speed and rapid re-concentration of fires.

The result was the crushing defeat of the French and the British armies. Both had wasted their investments in advanced technologies by forcing them into service of old operational and organizational concepts. Aircraft, tanks, and radio communications were the advanced technologies of that day, and the West saw fit to incorporate them into the service of traditionally valued efficiencies. These were efficiencies that relied for any effectiveness they might have in combat upon confronting an enemy whose structure, procedures, and concept of fighting was largely symmetrical to their own.

Today's advanced technology, based almost entirely upon the single technological factor of the integrated circuit, is even more amenable to application to enhance traditional modes (i.e., geometries) of military performance. For example, aircraft fly higher, farther, and faster, but still remain manned airplanes, the accelerating expense of which is directly associated as much if not more with protecting the human beings flying them as it is with the nation's capacity to impose our will on an enemy. Other examples are more accurate, longer range, more rapidly firing artillery which, despite all of its improved performance, remains a weapon whose situational relevance is inherently limited by reliance on age-old "kinetic" kill principles; or aircraft-carrying (and other) ships whose traditionally conceived purpose was to speed decisively into battle, but whose inherent vulnerabilities, especially given modern geopolitical and related domestic political concerns, now force them to remain ever further removed from the fray – or even the risk of one.

This danger of new capabilities harnessed to old concepts of efficiency and effectiveness begs strongly for a radically new analytical construct. Central to this "New Analysis" would be analytical techniques that would both demand and permit realistic differentiation between internally

referenced efficiencies and external effectiveness. Failing achievement of a capacity to regard and examine conflict from new perspectives and in new dimensions, we face the prospect of a 21st Century American military that, regardless of the amounts of money expended upon it, will be capable at best of doing wrong (or spurious) things well.

CLOSELY RELATED DISTINCTIONS

Quantitative vs. Qualitative; (Adequacy of) Input vs. (Appropriateness of) Output; Arithmetic vs. Geometric; Linear (Regular) vs. Nonlinear (Irregular); Necessity vs. Sufficiency; Knowledge vs. Understanding (and Insight and Wisdom); "Systems" vs. "Systems-of-Systems" (Analyses); Entity-focused vs. Relationship-focused (Analytical Emphases).

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This briefing, produced under IDA's Central Research Program, illustrates a number of cognitive distinctions as they apply to differences that are perceived to exist between the Industrial Age and its transition to the Information Age. These cognitive distinctions have specific implications when they are considered from a national security or a military perspective. As noted at the end of each discussion, all of the distinctions noted in the briefing are closely tied in their logic to at least several, if not all, of the others. They all address somewhat different dimensions of the same problem: discontinuity. Discontinuity, as used in the briefing, is a watershed event or confluence of events or trends that produces a new set of circumstances that challenge the continued relevance of past experience and the assumptions that it empirically supported. The fundamental point of these distinctions is to highlight the cognitive challenges of transitions, and that the transitions redefine progress as a new trajectory to the future rather than as mere advancement over the past.

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